



ABSTRACT.--Short term fire effects were assessed on 31 winter and spring wildfires in 1- to 8-year-old loblolly pine plantations on the South Carolina Coastal Plain near Kingstree. Over 1450 trees were measured immediately after the fire and again the following winter. Various site, stand history, fuel and fire danger data were also collected for each fire. This paper discusses those aspects of the data base pertaining to tree survival. Three fourths of the trees 1 to 4 years old on burned plots died the first year but those that lived are virtually all healthy and expected to reach economic maturity. Once these fire resistant pines reached age 3, survival exceeded 75 percent as long as crown scorch was less than 75 percent. Survival dropped to below 25 percent when crown consumption exceeded 25 percent for all age classes in this study.

INTRODUCTION

Fire management agencies need accurate data on the damage caused by wildfires to adequately evaluate the cost-effectiveness of their programs. Managers of southern pine stands need the same information to plan remedies after fires. The study described here was designed to provide some of the data that are needed for loblolly pine (*Pinus taeda* L.) plantations 1 to 8 years old. It is a cooperative study by the Southern Forest Fire Laboratory of the Southeastern Forest Experiment Station, Region 8 of the USDA Forest Service, and the South Carolina Forestry Commission.

The objectives of this cooperative effort are to:

1. Determine mortality and develop rules-of-thumb for predicting mortality.
2. Devise a damage classification system and analyze survival and growth by damage class through the first growing season after fire.
3. Develop a procedure for assessing short-term financial losses to fire in unmerchantable plantations.

4. Determine the relationship between fire suppression costs and fire danger and fire intensity levels.

This paper reports only survival data one growing season after fires; The damage rating system that was used was effective in predicting that survival.

STUDY FIRES

The data base consists of 31 wildfires that occurred between March 4, 1983, and April 11, 1984 in four counties on the Atlantic Coastal Plain near Kingstree, South Carolina. Four 1/40 acre plots were established within two weeks after each fire: one in an area of the plantation visually judged to have sustained severe damage, two in areas of less severe damage, and the last across the firebreak in the unburned stand as a comparison. Site, stand history, fuel, and fire danger data were collected for each fire, and fire damage and mensurational data were measured on each tree in the 120 plots (one burn was disked and replanted before these measurements were completed). After the first post-fire growing season, all plots were relocated and each tree was remeasured and assigned to one of five recovery classes: 0 = dead, 1 = barely alive, 2 = poor recovery to date, 3 = good recovery with original terminal leader fire killed, 4 = good recovery with terminal leader intact, and 5 = tree in

¹ A paper presented at the Eighth National Conference on Fire and Forest Meteorology held at Detroit, Michigan on April 29- May 2, 1985.

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unburned control. In addition, any fire scars were described and evidence of insect, disease and animal damage tallied.

Approximately one dozen trees were eliminated because they could not be relocated or because of recording errors leaving 1,458 trees. Of the 1,103 measurement trees subjected to fire, 368 (33%) survived the first post-fire growing season.

RESULTS

Season

The fires were first separated by season. March 20th was chosen as the transition date between winter and spring, not only because it happens to be the first day of spring but also because it appears to be a good choice for this area based on field evidence.

No summer fires were documented because they are thought to almost always kill the trees. It is also widely believed that southern pines subjected to fire while undergoing their initial shoot elongation and needle flush of the growing season are more prone to crown damage than trees in the dormant state. The data supports this theory but the difference was less than anticipated. Twenty-nine percent of the 248 spring fire trees survived, whereas 35% of the 855 winter fire trees were alive after the first growing season. Spring fire tree survival was not uniform, ranging from 0 to 100 percent (Table 1) with almost half (110 trees) the mortality occurring in the 1 and 2 year age classes where all fires were particularly lethal (figure 1).

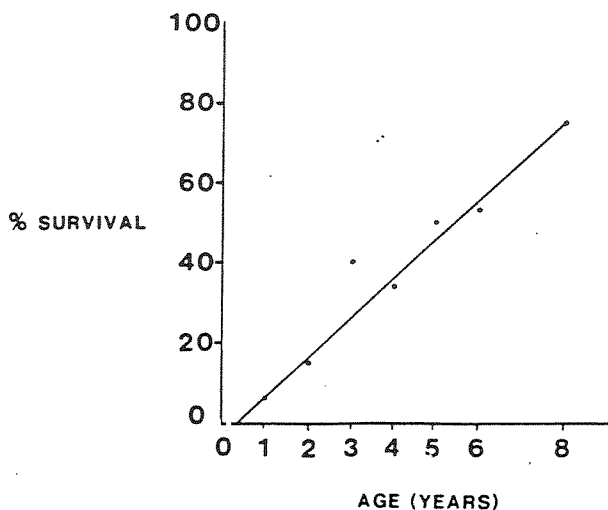


FIGURE 1.--SURVIVAL THROUGH 1 GROWING SEASON AFTER WILDFIRE BY PLANTATION AGE.³

These facts coupled with the limited spring fire data set (7 fires versus 23 during the dormant season) suggest caution in reaching conclusions regarding spring fires. Furthermore, plotting survival by month of fire shows that percent survival was lowest for early winter (November - December) burns, rose to a peak for late winter (March) burns and dropped to near the November rate for fires in the beginning of May (figure 2).

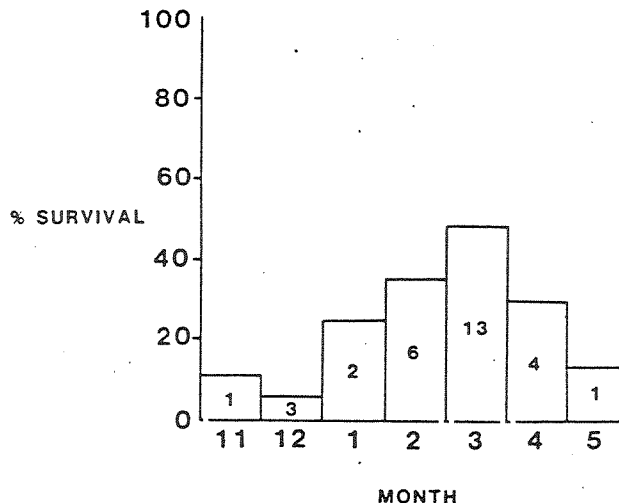


FIGURE 2.-- SURVIVAL BY MONTH OF FIRE. THE NUMBER IN EACH BAR IS THE NUMBER OF FIRES THAT OCCURED THAT MONTH.

Age

Since fire resistance is a product of tree size -- both height and girth -- it is no surprise that younger trees sustained the most damage. Ninety-three percent (350) of the 1- and 2-year-old trees had more than 75 percent crown scorch and 41 percent (105) of the 261 trees with greater than 75 percent crown consumption were 1 or 2 years old. This damage was reflected in poor survival rates for the youngest trees-- 6 percent of the trees burned at age 1, 15 percent for age 2, and 75 percent for age 8 (figure 1).

Scorch

Crown scorch (needles browned but not ignited) was visually estimated as a percentage of the total crown. Separation of the data by percent scorch revealed that 5 out of 6 trees with less than 75 percent scorch can be expected to survive (figure 3). As percent crown scorch reaches 100, however, survival drops to less than 20 percent.

³ All Lines hand-fitted to points.

TABLE 1.--Damage appraisal summary for young loblolly pine plantations near Kingstree, South Carolina.

Fire No.	Fire date	Age	Trees on burn plot	Mean Tree Height	Mean Diameter at 1.5" 4.5'	Mean Crown Scorch	Mean Crown Consumption	Survival
		Year	Number	Feet	Inches	Percent	Percent	Percent
1	3/04/83	2	38	4.1	.90	90	31	37
2	3/04/83	2	39	2.6	.58	94	28	23
3	3/30/83	6	31	13.1	3.38	73	16	100
4	4/13/83	4	37	11.4	2.37	69	23	68
5	4/28/83	2	40	4.4	.93	96	48	18
6	5/06/83	1	39	2.1	.39	92	52	13
7	11/23/83	2	33	6.1	1.40	88	38	12
8	12/02/83	2	31	2.1	.32	95	54	0
9	12/02/83	2	38	2.4	.43	83	36	8
10	1/07/84	3	35	5.1	1.24	92	50	17
11	12/27/83	2	39	4.2	.92	94	37	8
12	1/07/84	6	52	27.3	3.60	94	49	33
13	2/09/84	2	35	3.2	.68	99	32	9
14	2/12/84	5	35	10.0	1.55	62	10	89
15	2/02/84	4	35	4.8	1.33	83	42	37
16	2/08/84	3	39	6.0	1.37	82	24	44
17	2/13/84	3	34	3.6	.71	97	30	26
19	3/02/84	5	57	9.9	2.45	100	51	30
20	3/04/84	4	37	9.7	1.40	100	43	35
21	2/09/84	4	37	5.3	1.21	99	64	11
22	3/03/84	5	34	15.3	2.71	99	54	44
23	3/03/84	6	30	12.1	2.02	84	23	67
24	3/17/84	8	36	20.2	3.86	92	19	75
25	3/09/84	3	41	4.9	1.25	85	18	66
26	3/02/84	4	30	8.1	2.03	95	51	50
27	3/12/84	3	34	6.5	1.80	92	39	47
28	3/17/84	6	35	9.8	1.35	95	53	40
29	3/31/84	4	32	6.6	1.56	100	40	3
30	4/01/84	3	33	6.8	1.71	92	30	30
31	4/11/84	1	43	1.5	.30	100	67	0

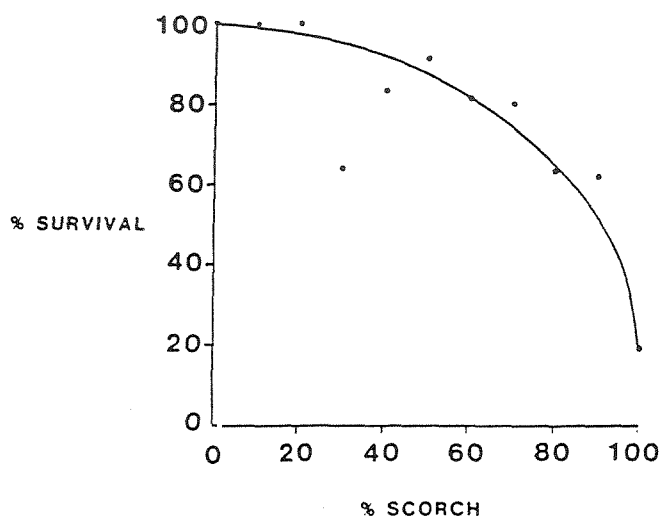


FIGURE 3.-- SURVIVAL BY PERCENT CROWN SCORCH.³

The combined effect of tree age (size) and scorch level on survival is dramatic. When crown scorch was less than 75 percent, all 83 trees 4 to 8 years old survived the first post-fire growing season (figure 4). However, when crown scorch exceeded 75 percent only the 8-year-old trees had a survival rate above 50%. These age class survival differences with comparable crown scorch levels can be attributed to the fact that the majority of trees younger than age 4 had yet to develop the thick insulating corky bark characteristic of older loblolly pines. The 7-year-old trees averaged 1.4 inches in diameter 1.5 inches above groundline, whereas those 4-year-old trees not tall enough to be measured at d.b.h. had an average diameter of 1.6 inches. Although the magnitude of this difference seems small, it may none-the-less be significant.

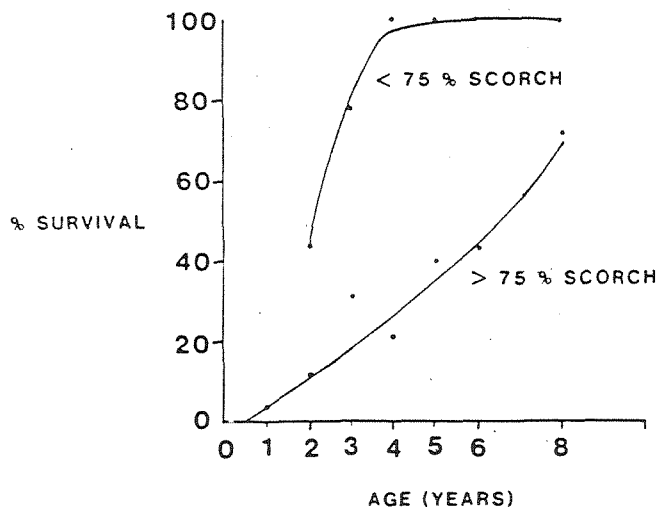


FIGURE 4.-- SURVIVAL BY PLANTATION AGE AT TWO LEVELS OF CROWN SCORCH.³

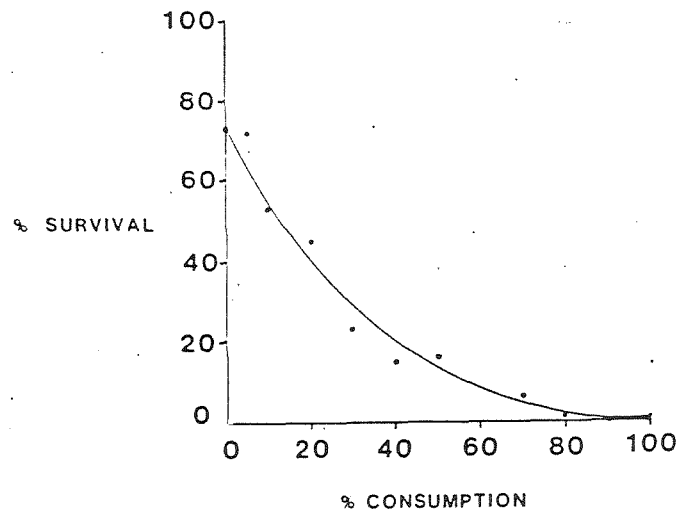


FIGURE 6.-- SURVIVAL BY PERCENT FOLIAGE CONSUMPTION.³

Consumption

Figure 5 shows that very little crown consumption took place until crown scorch approached 100 percent. With foliage consumption, the prospects of survival rapidly dropped, most likely due to branch cambium kill. In this study less than 50 percent of the trees survived the first post-fire growing season when consumption reached 20 percent (figure 6), and less than 25 percent survived when crown consumption exceeded 25 percent.

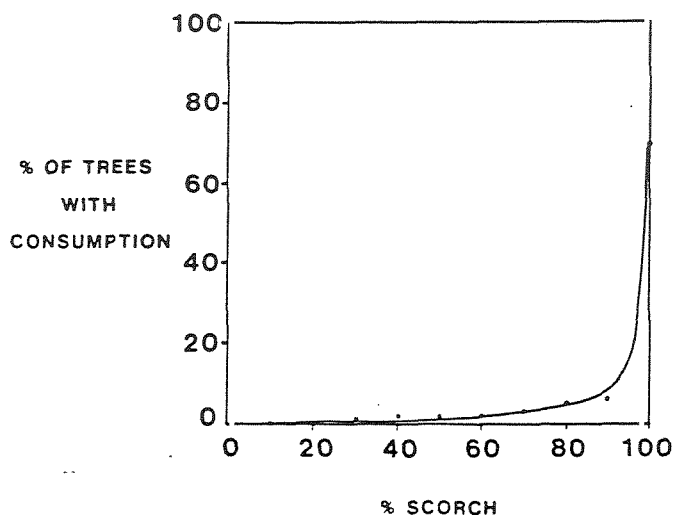


FIGURE 5-- PERCENT OF TREES WITH FOLIAGE CONSUMPTION TO ALL TREES BY PERCENT SCORCH.³

Tree mortality is much more likely when consumption is present because appreciably more heat is required to ignite needles than to scorch them (450°F vs 141°F). It is commonly believed that loblolly pine, as well as most other southern pines, can survive winter defoliation as long as the branch cambium and buds remain unharmed. Even though buds have a higher heat capacity than needles, and branch cambium has a protective layer of bark, the heat necessary to ignite the needles is sufficient to cause the death of these nearby meristematic tissues. Thus, foliage consumption is a good visual indicator that lethal crown temperatures have been reached.

Damage Classes

Whether a given tree will live or die depends upon several factors including the extent of crown damage and the tree's vigor at the time of the fire. Therefore, each tree was placed in one of six damage classes (Table 2) at the time the first post-fire survey was undertaken.

Damage class criteria proved to be workable. Placement of trees within a class was not difficult and all classes contained a large total sample. However, the small number of spring fire trees precludes meaningful discussion on a seasonal basis.

All 139 trees with 100 percent crown consumption were placed in damage class 1 while 26 of the 316 trees (8%) in this damage class had less than 25 percent consumption. As might also be expected, most of the 1-year-old trees (62 of 82 or 76%) were placed in damage class 1 while only 3 of the 36 8-year-old trees (8%) were placed in this category.

TABLE 2.--Tree survival by damage class, age and season for loblolly pine plantation wildfires near Kingstree, South Carolina.

Plantation wildfires near Kingstree, South Carolina.

Age	Number of Trees	DAMAGE CLASS 1											
		1		2		3		4		5		6	
		W ²	S	W	S	W	S	W	S	W	S	W	S
1	Live		1		2						2		26
	Dead		61		2		13				1		
2	Live	1	3	1	4	16		6		12		88	14
	Dead	50	24	47	9	94		9		19		1	
3	Live				1	31	5	5		39	4	57	<u>3/</u>
	Dead	28	3	22	5	38	7	8	2	11	6		
4	Live	1	1	1	1	26		1	24	15		46	27
	Dead	56	6	14	11	22	24		2	3			
5	Live			4		27		3		29		33	
	Dead	38		4		20				1			
6	Live		1		13	22		5	7	24	3	39	11
	Dead	39		6		21							
8	Live					14		1		12			13
	Dead	3		2		4							
Total live		2	6	6	21	136	5	21	31	131	9	263	91
Total Dead		214	94	95	27	199	44	17	4	34	7	1	

¹ Damage class Criteria: 1 = 100% crown scorch, >75% crown consumption, terminal leader drooping; 2 = intermediate between classes 1 and 3; 3 = 95 - 100% crown scorch, <25% crown consumption; 4 = intermediate between classes 3 and 5; 5 = <95% crown scorch, leader erect; 6 = tree in unburned control.

² W = winter fire, S = spring fire

³ No control plot on fire #30. whole plantation burned

SURVIVAL AND RECOVERY

Survival was predicted fairly well by assuming that all trees in damage classes 4 and 5 would survive (figure 7). Actually, some of these trees will die while some that are more severely damaged will live. Twenty-three percent of the trees in this study were placed in classes 4 or 5, while 33 percent of all study trees survived.

During the second post-fire survey--the one following the first growing season--each tree on the burned plots was assigned to one of five recovery classes. Of the 368 live trees, none were placed in recovery class 1, and 12 (3%) appeared in recovery class 2. Only four trees survived when the fire was intense enough to kill the terminal leader. Thus, it appears that virtually all mortality from these fires occurred during the first post-fire growing season. Future mortality, if any, from these fires will improve the prediction of survival using damage classes.

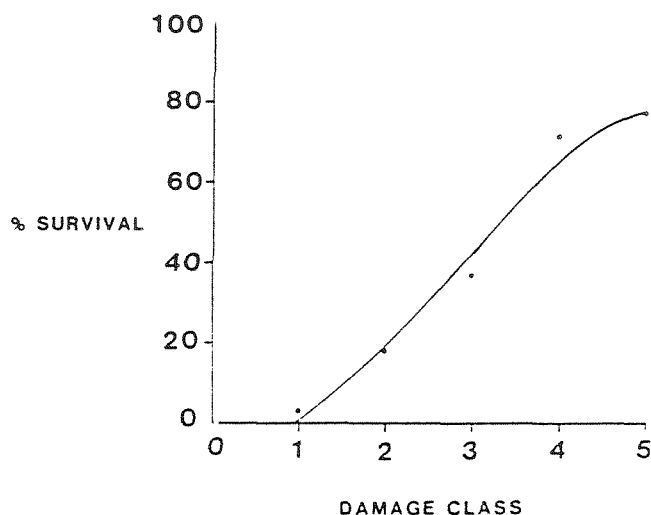


FIGURE 7.-- SURVIVAL BY FIRE DAMAGE CLASS.³

Fire damage is often thought to be a direct function of fireline intensity-- the higher the intensity, the greater the damage and the lower the survival. But this is not necessarily true in young southern pine plantations where fuel loads are generally very light and comprised mainly of herbaceous plants that will be rapidly consumed during any fire. Site preparation normally eliminates most fuel from the previous rotation. The litter layer is not continuous because crown closure does not take place until about age 7 or 8. Hardwood shrub sprouts or seedlings can be abundant but, if so, they tend to decrease fire intensity because they retard development of an herb layer-- the major fire carrier in young stands. In fact, unless these herbaceous fuels, particularly grasses, are exceedingly dense and in the cured state, backing fires are difficult to sustain.

Since available fuel remains fairly constant, Byram's (1959) fireline intensity is governed almost entirely by rate of spread. Yet the fastest rates of spread can actually result in less damage. Wind speeds are not appreciably diminished by the young tree crowns and the highest winds are generally associated with the passage of cold fronts. The heat generated by a fire under these conditions is rapidly mixed with this colder air and carried out ahead of the fire, resulting in a lower scorch line. The flames also bend over resulting in more distance between them and the tree crowns.

Slower moving fires, on the other hand, can be more damaging in these light fuel loads. Although these fires do not generate any more heat, they generally occur under warmer ambient air conditions and lower wind speeds. The hot combustion products rise into the tree crowns resulting in lethal temperatures. Fireline intensity is thus not always best indicator of damage in young pine plantations.

CONCLUSIONS

Conclusions that can be reached from this analysis regarding the survival of young plantation-grown loblolly pines subjected to winter or spring wildfires include:

1. The species is remarkably fire resistant. One fourth of the 800 trees ranging in age from 1 to 4 years were alive the winter following wildfire.
2. Young pines are more susceptible to early winter and spring wildfires than to late dormant season fires.
3. Mortality can be predicted within a few days after fire from crown scorch, needle consumption, and terminal leader condition.
4. Greater than 75 percent survival can be expected when crown scorch is less than 75 percent once the trees reach 3 years of age.
5. Less than 25 percent survival can be expected when crown consumption is greater than 25 percent and trees are less than 9 years old.
6. Virtually all trees alive after the first post-fire growing season are well on their way to recovery suggesting that most fire mortality occurs soon after the fire.

LITERATURE CITED

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1959. Combustion of forest fuels, in K. P. Davis, Ed., Forest Fire Control and Use. McGraw Hill, New York.

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